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Link Bundling in MPLS Traffic Engineering (TE)

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Abstract

For the purpose of Generalized Multi-Protocol Label Switching (GMPLS) signaling, in certain cases a combination of <link identifier, label> is not sufficient to unambiguously identify the appropriate resource used by a Label Switched Path (LSP). Such cases are handled by using the link bundling construct, which is described in this document. This document updates the interface identification TLVs, which are defined in the GMPLS Signaling Functional Description.

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1. Introduction

For the purpose of Generalized Multi-Protocol Label Switching (GMPLS) signaling, in certain cases a combination of <link identifier, label> is not sufficient to unambiguously identify the appropriate resource used by a Label Switched Path (LSP). Such cases are handled by using the link bundling construct, which is described in this document. This document updates the interface identification TLVs, which are defined in the GMPLS Signaling Functional Description.

1.1. Specification of Requirements

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

2. Link Bundling

As defined in [GMPLS-ROUTING], a traffic engineering (TE) link is a logical construct that represents a way to group/map information about certain physical resources (and their properties) that interconnect LSRs with information that is used by Constrained SPF (for the purpose of path computation) and by GMPLS signaling.

As stated in [GMPLS-ROUTING], depending on the nature of resources that form a particular TE link for the purpose of GMPLS signaling, in some cases a combination of <TE link identifier, label> is sufficient to unambiguously identify the appropriate resource used by an LSP. In other cases, a combination of <TE link identifier, label> is not sufficient. Consider, for example, a TE link between a pair of SONET/SDH cross-connects, where this TE link is composed of several fibers. In this case the label is a TDM time slot, and moreover, this time slot is significant only within a particular fiber. Thus, when signaling an LSP over such a TE link, one needs to specify not just the identity of the link, but also the identity of a particular fiber within that TE link, as well as a particular label (time slot) within that fiber. Such cases are handled by using the link bundling construct, which is described in this document.

Consider a TE link such that, for the purpose of GMPLS signaling, a combination of <TE link identifier, label> is not sufficient to unambiguously identify the appropriate resources used by an LSP. In this situation, the link bundling construct assumes that the set of resources that form the TE link could be partitioned into disjoint subsets, such that (a) the partition is minimal, and (b) within each subset, a label is sufficient to unambiguously identify the appropriate resources used by an LSP. We refer to such subsets as "component links", and to the whole TE link as a "bundled link". Furthermore, we restrict the identifiers that can be used to identify component links such that they are unique for a given node. On a bundled link, a combination of <component link identifier, label> is sufficient to unambiguously identify the appropriate resources used by an LSP.

The partition of resources that form a bundled link into component links has to be done consistently at both ends of the bundled link. Both ends of the bundled link also have to understand the other end's component link identifiers.

The purpose of link bundling is to improve routing scalability by reducing the amount of information that has to be handled by OSPF and/or IS-IS. This reduction is accomplished by performing information aggregation/abstraction. As with any other information aggregation/abstraction, this results in losing some of the

information. To limit the amount of losses, one needs to restrict the type of information that can be aggregated/abstracted.

2.1. Restrictions on Bundling

All component links in a bundle have the same Link Type (i.e., point-to-point or multi-access), the same Traffic Engineering metric, the same set of resource classes at each end of the links, and must begin and end on the same pair of LSRs.

A Forwarding Adjacency may be a component link; in fact, a bundle can consist of a mix of point-to-point links and FAs.

If the component links are all multi-access links, the set of IS-IS or OSPF routers that are connected to each component link must be the same, and the Designated Router for each component link must be the same. If these conditions cannot be enforced, multi-access links must not be bundled.

Component link identifiers MUST be unique across both TE and component link identifiers on a particular node. This means that unnumbered identifiers have a node-wide scope, and that numbered identifiers have the same scope as IP addresses.

2.2. Routing Considerations

A component link may be either numbered or unnumbered. A bundled link may itself be numbered or unnumbered, independent of whether the component links of that bundled link are numbered.

Handling identifiers for unnumbered component links, including the case in which a link is formed by a Forwarding Adjacency, follows the same rules as those for an unnumbered TE link (see Section "Link Identifiers" of [RFC3477]/[RFC3480]). Furthermore, link local identifiers for all unnumbered links of a given LSR (whether component links, Forwarding Adjacencies, or bundled links) MUST be unique in the context of that LSR.

The "liveness" of the bundled link is determined by the liveness of each of the component links within the bundled link; a bundled link is alive when at least one of its component links is determined to be alive. The liveness of a component link can be determined by any of several means: IS-IS or OSPF hellos over the component link, RSVP Hello, LMP hellos (see [LMP]), or from layer 1 or layer 2 indications.

Once a bundled link is determined to be alive, it can be advertised as a TE link and the TE information can be flooded. If IS-IS/OSPF hellos are run over the component links, IS-IS/OSPF flooding can be restricted to just one of the component links. Procedures for doing this are outside the scope of this document.

In the future, as new Traffic Engineering parameters are added to IS-IS and OSPF, they should be accompanied by descriptions as to how they can be bundled, and possible restrictions on bundling.

2.3. Signaling Considerations

Because information about the bundled link is flooded, but information about the component links is not, typically, an LSP's ERO will identify the bundled link to be used for the LSP, but not the component link. While Discovery of component link identities to be used in an ERO is outside the scope of the document, it is envisioned that such information may be provided via configuration or via future RRO extensions. When the bundled link is identified in an ERO or is dynamically identified, the choice of the component link for the LSP is a local matter between the two LSRs at each end of the bundled link.

Signaling must identify both the component link and label to use. The choice of the component link to use is always made by the sender of the Path/REQUEST message. If an LSP is bidirectional [RFC3471], the sender chooses a component link in each direction. The handling of labels is not modified by this document.

Component link identifiers are carried in RSVP messages, as described in section 8 of [RFC3473]. Component link identifiers are carried in CR-LDP messages, as described in section 8 of [RFC3473]. Additional processing related to unnumbered links is described in the "Processing the IF_ID RSVP_HOP object"/"Processing the IF_ID TLV", and "Unnumbered Forwarding Adjacencies" sections of [RFC3477]/[RFC3480].

[RFC3471] defines the Interface Identification type-length-value (TLV) types. This document specifies that the TLV types 1, 2, and 3 SHOULD be used to indicate component links in IF_ID RSVP_HOP objects and IF_ID TLVs.

Type 1 TLVs are used for IPv4 numbered component link identifiers.

Type 2 TLVs are used for IPv6 numbered component link identifiers.

Type 3 TLVs are used for unnumbered component link identifiers.

The Component Interface TLVs, TLV types 4 and 5, SHOULD NOT be used. Note, in Path and REQUEST messages, link identifiers MUST be specified from the sender's perspective.

Except in the special case noted below, for a unidirectional LSP, only a single TLV SHOULD be used in an IF_ID RSVP_HOP object or IF_ID TLV. This TLV indicates the component link identifier of the downstream data channel on which label allocation must be done.

Except in the special case noted below, for a bidirectional LSP, only one or two TLVs SHOULD be used in an IF_ID RSVP_HOP object or IF_ID TLV. The first TLV always indicates the component link identifier of the downstream data channel on which label allocation must be done. When present, the second TLV always indicates the component link identifier of the upstream data channel on which label allocation must be done. When only one TLV is present, it indicates the component link identifier for both downstream and upstream data channels.

In the special case where the same label is to be valid across all component links, two TLVs SHOULD be used in an IF_ID RSVP_HOP object or IF_ID TLV. The first TLV indicates the TE link identifier of the bundle on which label allocation must be done. The second TLV indicates a bundle scope label. For TLV types 1 and 2, this is done by using the special bit value of all ones (1) (e.g., 0xFFFFFFFF for a type 1 TLV). Per [RFC3471], for TLV types 3, 4, and 5, this is done by setting the Interface ID field to the special value 0xFFFFFFFF. Note that this special case applies to both unidirectional and bidirectional LSPs.

Although it SHOULD NOT be used, when used, the type 5 TLV MUST NOT be the first TLV in an IF_ID RSVP_HOP object or IF_ID TLV.

2.3.1. Interface Identification TLV Format

This section modifies section 9.1.1. of [RFC3471]. The definition of the IP Address field of the TLV types 3, 4, and 5 is clarified.

> For types 3, 4, and 5, the Value field has an identical format to the contents of the C-Type 1 LSP_TUNNEL_INTERFACE_ID object defined in [RFC3477]. Note that this results in the renaming of the IP Address field defined in [RFC3471].

2.3.2. Errored Component Identification

When Interface Identification TLVs are used, the TLVs are also used to indicate the specific components associated with an error. For RSVP, this means that any received TLVs SHOULD be copied into the IF_ID ERROR_SPEC object (see Section 8.2 in [RFC3473]). The Error Node Address field of the object SHOULD indicate the TE Link associated with the error. For CR-LDP, this means that any received TLVs SHOULD be copied into the IF_ID Status TLV (see Section 8.2 in [RFC3472]). The HOP Address field of the TLV SHOULD indicate the TE Link associated with the error.

3. Traffic Engineering Parameters for Bundled Links

In this section, we define the Traffic Engineering parameters to be advertised for a bundled link, based on the configuration of the component links and of the bundled link. The definition of these parameters for component links was undertaken in [RFC3784] and [RFC3630]; we use the terminology from [RFC3630].

3.1. OSPF Link Type

The Link Type of a bundled link is the (unique) Link Type of the component links. Note that this parameter is not present in IS-IS.

3.2. OSPF Link ID

For point-to-point links, the Link ID of a bundled link is the (unique) Router ID of the neighbor. For multi-access links, this is the interface address of the (unique) Designated Router. Note that this parameter is not present in IS-IS.

3.3. Local and Remote Interface IP Address

Note that in IS-IS, the Local Interface IP Address is known as the IPv4 Interface Address and the Remote Interface IP Address is known as the IPv4 Neighbor Address.

If the bundled link is numbered, the Local Interface IP Address is the local address of the bundled link; similarly, the Remote Interface IP Address is the remote address of the bundled link.

3.4. Local and Remote Identifiers

If the bundled link is unnumbered, the link local identifier is set to the identifier chosen for the bundle by the advertising LSR. The link remote identifier is set to the identifier chosen by the neighboring LSR for the reverse link corresponding to this bundle, if known; otherwise, this is set to 0.

3.5. Traffic Engineering Metric

The Traffic Engineering Metric for a bundled link is that of the component links.

3.6. Maximum Bandwidth

This parameter is not used. The maximum LSP Bandwidth (as described below) replaces the Maximum Bandwidth for bundled links.

3.7. Maximum Reservable Bandwidth

For a given bundled link, we assume that either each of its component links is configured with the Maximum Reservable Bandwidth, or the bundled link is configured with the Maximum Reservable Bandwidth. In the former case, the Maximum Reservable Bandwidth of the bundled link is set to the sum of the Maximum Reservable Bandwidths of all component links associated with the bundled link.

3.8. Unreserved Bandwidth

The unreserved bandwidth of a bundled link at priority p is the sum of the unreserved bandwidths at priority p of all the component links associated with the bundled link.

3.9. Resource Classes (Administrative Groups)

The Resource Classes for a bundled link are the same as those of the component links.

3.10. Maximum LSP Bandwidth

The Maximum LSP Bandwidth takes the place of the Maximum Bandwidth. For an unbundled link, the Maximum Bandwidth is defined in [GMPLS-ROUTING]. The Maximum LSP Bandwidth of a bundled link at priority p is defined to be the maximum of the Maximum LSP Bandwidth at priority p of all of its component links.

The details of how Maximum LSP Bandwidth is carried in IS-IS is given in [GMPLS-ISIS]. The details of how Maximum LSP Bandwidth is carried in OSPF is given in [GMPLS-OSPF].

4. Bandwidth Accounting

The RSVP (or CR-LDP) Traffic Control module, or its equivalent, on an LSR with bundled links must apply admission control on a per-component link basis. An LSP with a bandwidth requirement b and setup priority p fits in a bundled link if at least one component link has a maximum LSP bandwidth >= b at priority p. If there are several such links, the implementation will choose which link to use for the LSP.

In order to know the maximum LSP bandwidth (per priority) of each component link, the Traffic Control module must track the unreserved bandwidth (per priority) for each component link.

A change in the unreserved bandwidth of a component link results in a change in the unreserved bandwidth of the bundled link. It also potentially results in a change in the maximum LSP bandwidth of the bundle; thus, the maximum LSP bandwidth should be recomputed.

If one of the component links goes down, the associated bundled link remains up and continues to be advertised, provided that at least one component link associated with the bundled link is up. The unreserved bandwidth of the component link that is down is set to zero, and the unreserved bandwidth and maximum LSP bandwidth of the bundle must be recomputed. If all the component links associated with a given bundled link are down, the bundled link MUST not be advertised into OSPF/IS-IS.

5. Security Considerations

This document defines ways of utilizing procedures defined in other documents, referenced herein. Any security issues related to those procedures are addressed in the referenced documents. Thus, this document raises no new security issues for RSVP-TE [RFC3209] or CR-LDP [RFC3212].

6. IANA Considerations

This document changes the recommended usage of two of the Interface_ID Types defined in [RFC3471]. For this reason, the IANA registry of GMPLS Signaling Parameters has been updated to read:

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4      12      COMPONENT_IF_DOWNSTREAM - DEPRECATED
5      12      COMPONENT_IF_UPSTREAM   - DEPRECATED
```

7. References

7.1. Normative References

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